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TRANSMISSION POWER CONTROL IN A RADIO COMMUNICATION SYSTEM

Field of the Invention

5   The present invention relates to power control in a communication system, and in particular, but not exclusively, to power control of a station of the communication system in a power limitation situation.

10   Background of the Invention

In a mobile telecommunication system, such as CDMA (Code Division Multiple Access) or WCDMA (Wide-band CDMA) or TDMA (Time division Multiple Access) system, transmission power

15   levels between a base (transceiver) station (BS) and a mobile station (MS) associated with said base station can be continuously adjusted during an ongoing connection between the base station and the mobile station. This is done in order to provide a sufficient quality for the transmission in

20   various conditions. To reduce power consumption and interference it is also preferred to keep the required transmission power levels as low as possible at the same time. By means of this it is possible to avoid "wasting" any network resources and power resources, and to enable as great

25   a number of mobile stations as possible to communicate simultaneously with the base station having only limited power resources. The power resources of the base station are limited both in transmission (downlink) and receiving (uplink) directions.

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In the uplink the limitation means that a base station cannot receive and process more than a predefined number of connections from mobile stations. The uplink direction can be

limited by increased quality requirements, e.g. in a
situation in which a great number of mobile stations is
communicating via the base station and request for a higher
transmission quality. If the power levels are increased in

5   the cell in order to improve the quality, this increases
interference in the uplink. Therefore, in addition to the
incapability of the base station to receive more than a
limited amount of transmission power from the mobile
stations, too high transmission powers from the mobile

10 stations may cause too high interference to the radio traffic
within the cell and/or have an adverse influence to the
overall performance of the base station.

One power control mechanism is based on power control (PC)

15 commands transmitted between two stations to cause the other
station to alter or adjust or change its transmission power.
The PC commands can be transmitted e.g. in a WCDMA closed
loop functioning between the BS and the MS. The closed loop
PC (CLPC) commands can be sent both in the uplink (towards

20 the base station) and in the downlink (towards the mobile
station), whereafter the BS or the MS will process the
received command and reduce/increase its transmission power
towards the receiving station accordingly.

25 The power control between the stations, such as the closed
loop PC, can be controlled by another power control command
generated by a controller of the communication system. For
example, in the currently proposed WCDMA system it is
envisaged that an outer loop power control (OLPC) command

30 generated by a radio network controller (RNC) of the WCDMA
system will attempt to set the connection quality target of a
physical connection between the BS and MS to be such that a
required FER (Frame Error Ratio) target or BER (Bit Error

Ratio) target or any other similar target of the connection
is met with a minimal connection quality target. The closed
loop power control command is then adjusted at the base
station in accordance with the outer loop power control
5   command received from the controller. The connection quality
target may sometimes be referred to as a connection setpoint.

The connection quality target or setpoint can be announced
e.g. by means of so called Eb/No (Signalling Energy/Noise)
10   target or SIR (Signal to Interference Ratio) target or
desired signal level target or a similar parameter indicating
a quality measure which can be estimated for the connection.
The relationship is such that the connection quality target
(e.g. the SIR target) has to be set such that the FER or the
15   BER or similar parameter of the connection remains at an
appropriate level. The actual connection quality value (e.g.
SIR) is then controlled in accordance with the target value,
and one or several of used connection parameters having
influence to the quality of the connection should follow any
20   changes in the target value. In most cases it is sufficient
if the transmission power is increased/decreased in order to
meet the target value. The idea behind the arrangement is
that by increasing the connection quality target value the
transmission power (or any other appropriate transmission
25   parameter having an influence over the connection quality)
will increase and thus the connection quality will increase
and the FER will improve.

However, if the appropriate target of the connection quality
30   cannot be met due to e.g. a power limitation situation the
connection quality target will start increasing, even though
this rise in the connection quality target will not help in
causing a better connection between the MS and the BS. The

power limitation condition at the BS can be caused e.g. by an overload situation or a failure. If the power limitation is only temporary the quality target will also be unnecessarily high once this condition has been removed. The temporary

5 power limitation can occur e.g. when too many mobile stations are trying to become connected to one BS, e.g. when a bus or train with several mobile users suddenly enters the radio coverage area of the base station. The power limitation may also occur e.g. when the radio connection between the BS and

10 one or several mobile stations weakens temporarily, for instance, the MS enters temporarily a tunnel or cellar, which will cause a rapid rise in the transmission powers. The failures causing a power limitation situation may occur in the base station, elsewhere in the communication system or in

15 the mobile stations. The power limitation situation may result in an excessively high power levels within the cell until the quality target has returned to its normal (nominal) level. In addition, an uncontrolled power limitation situation (i.e. the powers of the mobile stations may rise

20 freely) will lead to a situation in which the mobile stations positioned in the edge area of the cell start loose the connection i.e. the mobile stations "drop" from the cell. This leads to a decrease in the size of the cell.

25 Earlier proposals to solve the problems caused by the power limitation situation have been based on setting absolute limits on the values of the SIR targets. However, the absolute limits have to be relatively loose due to the variations in the required quality target for satisfactory

30 quality of the communication. There has not been any efficient means for rapidly preventing an excessive increase of the target or setpoint value in an overload or other sudden power limitation situation. Instead, the target value

has increased further as the target is increased accordingly despite the fact that no more power is available or can be received. In addition, when the power limitation situation is over, the recovery from the increased and unnecessarily high
5   target values may take some time.

Summary of the Invention

The embodiments of the present invention aim to address one
10   or several of the above problems.

According to one aspect of the present invention, there is provided a method in a communication system, said system comprising a controller and a first station for communication
15   with a second station with variable transmission power over a radio connection, wherein the controller provides the first station with a target for a transmission parameter of the radio connection and the first station adjusts the transmission power of the second station on basis of the
20   target, comprising: monitoring for a predefined condition; upon occurrence of the predefined condition, preventing use of a target for the transmission parameter exceeding a limit value for the target for the transmission parameter.

25   According to a more specific embodiment the use of a target for the transmission parameter exceeding the limit value is prevented at the first station. The use of a target for the transmission parameter exceeding the limit value can also be prevented at the controller. The limit value may equal with
30   the target for the transmission parameter in use at the moment of detecting the predefined condition. The predefined condition may comprise a temporary power limitation situation at the first station, an overload situation at the first

station or a failure in the communication system. The
monitoring of the occurrence of the predefined condition can
be based on determination of the interference power of the
radio connection.

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According to a further embodiment a difference between the
value of the target for the transmission parameter provided
by the controller and the value of the target for the
transmission parameter used for power control by the first
10   station is detected after the predefined condition is over,
whereafter the difference between the said two target values
is reduced. The difference can be reduced based on history
information of the target used for the power control prior
the detection of the condition. The difference between the
15   said two target values can be reduced gradually.

According to another aspect of the present invention there is
provided a communication system, comprising: a controller
arranged to control transmission power of stations; a first
20   station and a second station capable of providing a
communication path therebetween, wherein the controller is
arranged to provide the first station with a target for use
in control of the transmission power of the second station;
monitoring means for monitoring for a predefined condition;
25   and means for preventing use of a target for the transmission
parameter exceeding a limit value for the target for the
transmission parameter upon occurrence of the predefined
condition.

30   The communication system may comprise further detecting means
for detecting a difference between the target and the further
target and recovery means for reducing the difference after
the predefined condition is over.

According to a still another aspect of the present invention
there is provided a station of a communication system, said
station controlling transmission power of a further station
5   transmitting towards the station, wherein the station is
arranged to: receive a target for a transmission parameter
provided by a controller of the communications system for use
in the control of transmission power of the further station;
monitor for a predefined condition; and upon occurrence of
10 the predefined condition, to prevent use of targets for the
transmission parameter exceeding a limit value for the target
for the transmission parameter.

The embodiments of the invention provide several advantages.
15 Should a power limitation situation occur, the embodiments
prevent the situation getting even worse by preventing a
unnecessary rise of the connection quality target or similar
parameter influencing the transmission power in the cell. The
powers in the cell may be limited in a level that still can
20 be handled by the base station. The embodiments may also
prevent an increase in the interference in the cell. Since
the embodiments enable power resource situation within the
cell to remain stable, it is possible to prevent
disconnection of the ongoing connections, or to limit the
25 disconnecting procedures to the connections having a lowest
priority. In addition, the embodiments provide a fast
response to a power limitation situation without any
excessive delays due to e.g. signalling between a base
station and a network controller or several controllers. In
30 addition, the specific embodiments provide a controlled and
"smooth" recovery procedure after the power limitation
situation has ended.

Brief Description of Drawings

For better understanding of the present invention, reference
will now be made by way of example to the accompanying
5 drawings in which:
        Figure 1 shows schematically a part of a communication
system in which the invention can be implemented;
        Figure 2 is a block diagram of the base station and the
controller of the communication system of Figure 1;
10   Figure 3 illustrates schematically an embodiment of an
outer loop power control mechanism in an overload situation;
        Figure 4 illustrates schematically a further embodiment
of an outer loop power control mechanism in an overload
situation;
15   Figure 5 is a table presenting an example of the
operation of the present invention at the transceiver of the
communication system;
        Figure 6 is a table presenting an example of the
operation of the present invention at the controller of the
20 communication system;
        Figure 7 is a flowchart illustrating the operation of an
embodiment; and
        Figure 8 is a flowchart illustrating the operation of a
further embodiment.
25

Description of Preferred Embodiments of the Invention

Figure 1 is a block diagram illustrating a context in which
the present invention may be used. That is, a WCDMA system
30 (Wideband CDMA) mobile communication system allows a
plurality of mobile stations MS1, MS2, MS3 to communicate
with a base transceiver station (BS) 4 in a common cell over
a radio interface via respective channels CH1, CH2, CH3. The

base station can sometimes be referred to as node B. In the
CDMA based systems these channels are distinguished from one
another by the use of scrambling codes in a manner which is
know *per se*. Communication between the mobile stations 1-3
5   and the base station 4 may comprise any kind of data such as
speech data, video data or other data. The power control
commands between the mobile stations and the base station are
handled by a closed loop power control mechanism.

10   The base station 4 is controlled by a controller 5 of the
communication system. In the CDMA terminology this controller
is often referred to as a radio network controller (RNC). The
general arrangement is such that while the base station 4
controls the individual mobile stations 1 - 3 in its radio
15   coverage area via the radio channels, the network controller
5 functions as a "central" controller controlling several
base stations. The mobile stations 1 - 3 can be controlled by
the controller 5 through the base station 4.

20   In the currently proposed WCDMA system the base station 4
receives appropriate control commands from the controller 5
via an outer loop (OL) power control (PC) mechanism. As
response to the received commands the base station 4 proceeds
accordingly to control the connections with individual mobile
25   stations 1 - 3 via the closed loop (CL) between the
respective mobile station and the base station. According to
one possibility the commands may be transmitted in the closed
loop in the frequency of 1.5 kHz, and in the outer loop in
the frequency of about 10 to 100 Hz. However, it is noted
30   that any other frequencies may be used here. The following
description of the embodiments will concentrate in more
detail on the outer loop power control (OLPC) mechanism
between the base transceiver station 4 and the controller 5.

Figure 2 shows in more detail a base station 4 and a radio network controller 5 interacting with each other. The base station 4 of Figure 2 includes a base station control unit

5 (BCU) 6, a transmission power estimation unit (TRX) 7 and a radio channel unit (CHU) 8. The functionalities provided by the respective units as well as the controller 5 are described in the following by using WCDMA terminology. It should, however, be appreciated that the following is only an

10 example of the embodiments and thus the scope of the invention is not restricted by the use of the WCDMA terminology, and that the invention can also be applied to communication systems based on other standards.

15 The base station 4 of Figure 2 includes a load control (LC) functionality 10 controlling the outer loop power control functionality 12 of the base station (OLPC/BS). The RNC 5 is shown to include a corresponding pair of a load control functionality 11 and an outer loop power control

20 functionality (OLPC/RNC) 13. Communication paths or channels 14 and 15 are provided between the respective LC and OLPC functionalities of the BS 4 and the RNC 5. The RNC is arranged to generate an Eb/No-setpoint 16 which is subsequently transmitted to the BS in a outer loop power

25 control command 15. In the example the command is shown to be in the form of a relative "UP" or "DOWN" command, but the OLPC command from the RNC could also include an absolute value for the targeted Eb/No-setpoint or a relative amount of increase or decrease of the setpoint value.

30

The OLPC/BS at the BS 4 receives the Eb/No-setpoint and may store the setpoint in an appropriate storage functionality. The Eb/No-setpoint which has been received from the RNC 5 is

shown by a functionality 16 of the BS 4. For the purposes of
clarity, the setpoint functionality of the base station 4 is
designated correspondingly with the setpoint functionality 16
of the RNC 5.

5

In addition to the Eb/No-setpoint 16, the BS 4 of Figure 2 is
shown to comprise a second or further Eb/No-setpoint or a BS
Eb/No-setpoint functionality 17. The arrangement is such that
the second Eb/No-setpoint functionality 17 is used for
10   controlling the closed loop power control and/or uplink fast
load control functionality 18 instead of a direct use of the
Eb/No-setpoint 16 received from the RNC. The first Eb/No-
setpoint 16 of the BS 4 is always controlled by the RNC 5 and
should always have the same setpoint value as the setpoint 16
15   at the RNC 5. The second EB/No-setpoint 17 is the setpoint
actually provided to the closed loop functionality 18. The
arrangement is such that in normal operation the second
setpoint 17, i.e. OLPC/BS, follows the first setpoint, i.e.
OLPC/RNC functionality 16.

20

When the quality of the bearer between the mobile station(s)
in the cell and the base station goes bad enough the outer
loop PC functionality 13 in the RNC (OLPC/RNC) 5 starts to
increase the Eb/No-setpoints 16 of the radio link
25   connection(s). An increase of the Eb/No-setpoints will
eventually increase the uplink transmission powers from one
or several of the mobile stations in the cell
correspondingly. Similarly, a decrease of the Eb/No-setpoints
would decrease the transmission powers.

30

According to an embodiment of the invention the Load Control
(LC) algorithm 10 at the base transceiver station (BS) 4 may
start preventive load control actions in order to avoid a

situation in which mobile stations have to be "dropped" out
i.e. disconnected from the cell. For example, the WCDMA Load
Control (LC) algorithm 10 may set limit values for the BS
outer loop power control parameters or freeze the base
5   station (OLPC/BS) so that the OLPC/BS no longer follows
Eb/No-setpoint increase commands by an outer loop power
control 16 from the RNC 5 (OLPC/RNC).

The limiting or freezing procedure of the setpoint or target
10   value may be initiated at the BS e.g. when a uplink total
interference power level (PrxTotal) at the BS digital
receiver exceeds a given threshold value. The total received
wideband interference power (PrxTotal) is measured by the
base station BS on cell basis for Radio Resource Indication
15   purposes in a per se known manner. This measurement is
reported periodically to the controller RNC, e.g. by using
known NBAP/RADIO RESOURCE INDICATION procedure. The length of
the period can be, for instance, selected from a range
between 100ms to 1s. The RNC may then use the measurement
20   results for functionalities such as Admission Control (AC),
Load Control (LC), and Packet Scheduler (PS) and so on.

The interference power level can be estimated by the TRX unit
7 of Figure 2. The threshold value for the interferece power
25   is designated in the following example by PrxTargetBS. The
exemplifying threshold value is defined by equation:

PrxTargetBS = PrxTarget + PrxOffset,
wherein
30   PrxTarget is the planned target load of the system, and
PrxOffset is the allowed marginal above PrxTarget, after
which overload prevention actions are to be started.

When the total interference value PrxTotal in Figure 2
exceeds PrxTargetBS the OLPC/BS is frozen, and the BS 4 is no
longer allowed to transmit closed loop power control
commands (CLPCs) towards the MS 1, even though the BS 4 may
5   still receive OLPCs from the RNC 5. According to a more
specific embodiment the outer loop PC functionality 18 in the
BS (OLPC/BS) is frozen by the BS load control (BS LC) 10
after the PrxTargetBS is exceeded. In practice this means
that the OLPC/BS ignores any Eb/No-setpoint increase commands
10   of the OLPC/RNC until the PrxTotal is below the exceeded
threshold.

According to a preferred embodiment present in the flow chart
of Figure 7, the connection quality target value is not
15   frozen to any precise value in a power limitation situation,
but instead the target used for the connection control is
prevented to exceed a certain predefined threshold value. In
other words, the power control mechanism is not switched off
in a power limitation situation. Instead, the connection
20   quality target can be changed and the transmission power
levels adjusted in the cell as long as the target does not
exceed the temporary set upper limit.

According to one alternative only "DOWN" or "reduce target"
25   type of commands are allowed in the closed loop while any
commands aimed to increase uplink transmission powers in the
cell will not become transmitted towards the mobile stations.

Figure 2 presents in more detail the use of the PrxTotal
30   measurement. As mentioned above, OLPC/BS is frozen or a
temporary upper limit is set when PrxTotal > PrxTargetBS. In
the BS the OLPC/BS can be frozen or limited on frame-bases,
i.e. the determination of the PrxTotal can be accomplished

over each frame. In this case the total wideband interference
power received at the BS would be averaged over one radio
frame (e.g. 10ms) in the TRX-unit 7 of the BS 4, and reported
periodically (e.g. every 10ms) to the BCU unit 8 of the BS 4.

5 PrxTotal can then be calculated on 10ms-cycles e.g. by using
sliding average window and an ALPHA-TRIMMED-MEAN filter or
any other appropriate means for filtering.

The same applies to the OLPC/RNC, but it can be frozen or
10 limited only after a radio resource (RR) indication message
14 is received in the RNC load control 11. The RR indication
can be sent e.g. every 0.1s - 1s. The outer loop PC can then
be switched on/off based on monitoring of the received
PrxTotal.

15

It is to be appreciated that the RNC 5 may alternatively
receive some other type indication from the BS 4 instructing
the RNC 5 to switch the OLPC/RNC on/off than the PrxTotal
indication. It is also noted that the total interference
20 value is only an example of the possible triggering
parameter, and other indications of a power limitation
situation can also be used for triggering the limitation or
freezing procedure of the connection quality setpoint at the
base station and/or the controller.

25

As explained, the outer loop PC of the RNC (OLPC/RNC) can be
limited or frozen after the overload situation is indicated
to the RNC even though this is not always necessary. For
instance, the arrangement can be such that the OLPC/RNC does
30 not carry out any Eb/No-setpoint increases, but only replaces
"change" type indications with a "no change" type indication.
It is also possible to arrange the OLPC/RNC such that only
Eb/No-setpoint decreases are allowed. The RNC arrangement may

also be such that a temporary upper limit is set for the
Eb/No-setpoint allowing a normal operation of the OLPC/RNC as
long as the limit is not exceeded. The limit may equal or be
different to that in use in the base station. If the limit is
5   exceeded, use of any excessive setpoint values is prevented
at the RNC and thus this embodiment corresponds the use of an
upper limit at the BS.

It is also possible to have the outer loop functionality
10   frozen or limited such that all or a selected number of
mobile stations communicating with the base station 4 are
influenced, i.e. that the power levels of all or selected
connections are cut, frozen or held below a certain limit.
The connections may also be set into a priority order. In the
15   latter instance the procedure can be such that the power
levels of the lowest priority connections are limited and/or
frozen first, and the highest priority connections are
limited as last, if at all. The priority order classification
of the connections may be based on the type of the
20   subscription. A possibility is to use the type of the ongoing
connection as basis for the prioritisation. For instance,
speech, data and video connections may have different
priorities. The same applies for "normal" calls, calls to
emergency numbers, business calls, "hotline" calls and so on.
25

The OLPC/RNC freezing and/or limitation procedure may occur
after the interference level or some other indication of a
power limitation situation is signalled from the BS to the
RNC. As explained, the RR indication message is sent
30   periodically (e.g. in periods between 100ms to 1s). Now, if
the interference value PrxTotal exceeds PrxTargetBS (=
PrxTarget + PrxOffset) as discussed above, the OLPC/RNC can

be limited or frozen only after the indication of this has
been received and processed at the RNC.

If the setpoint values at the BS are not allowed to follow
5   the OLPC/RNCs from the RNC, the RNC Eb/No-setpoint 16 may
start to differ from the Eb/No-setpoint 17 used by the BS for
the closed loop functionality 18. This is due the fact that
in most cases there will be a delay before the RNC 5 receives
the overload indication 14 from the BS 4 and thus before the
10 RNC may take similar actions to the BS. In other words, if an
overload or another power limitation situation is detected,
the two Eb/No-setpoints 16 and 17 of Figure 2 start to drift
because the outer loop PC generated by the RNC is no longer
allowed to adjust the closed loop PC 18. This difference will
15 be referred to in the following as drifting.

After the power limitation situation is over, the operation
of the OLPC/BS and OLPC/RNC is returned to a normal mode. The
Eb/No-setpoint drifting between the BS and the RNC has to be
20 removed during the recovery after the overload situation is
over (PrxTotal < PrxTargetBS) and the outer loop PC is again
allowed to control the power levels. The base station can
remove the drift internally because it knows the actual
setpoint value 17 in at the base station 4 and also the
25 setpoint value 16 in use at the RNC 5. Thus it is possible to
set either the setpoint value 16 to equal with the actual
setpoint 17 or vice versa before the operation is returned to
a normal mode. In addition, history information can be used
for the recovery, i.e. the setpoint values in the BS and the
30 RNC can be returned to a value used by them before the power
limitation situation was detected. It is also possible to use
a default or nominal value to which the setpoint in the RNC

and/or in the BS is returned at the beginning of the normal
mode.

However, in order to provide a controlled recovery and to
5   avoid any too "sharp" changes in the setpoint values, it may
be preferred that the returning to the appropriate setpoint
value is not done at once. This is especially the case when
the quality of the connection is substantially bad. Therefore
it may be preferred to use some procedure to gradually
10   decrease the drifting.

As shown by the flow chart of figure 8, the BS 4 may initiate
the recovery procedure by checking for a possible drift of
the Eb/No-setpoints when an Eb/No-setpoint down command is
15   received from the RNC 5. If the check is positive, i.e. an
existing drift is detected, the drifting is reduced instead
of the actual Eb/No-setpoint. When an Eb/No-setpoint up
command is received in BS, then the actual Eb/No-setpoint is
always increased if the cell is not overloaded.
20
Before explaining in more detail the embodiments aimed for
solving the drifting problem, the arrangements of Figures 3
and 4 will be briefly discussed. It is noted that even though
Figures 3 and 4 disclose a more complex communication network
25   arrangement than Figure 2, the following embodiments can also
be implemented in the Figure 2 implementation.

Figure 3 shows a situation in which a mobile station MS is
controlled by two separate base stations 4 and 4' (e.g.
30   during a handover procedure). A1 and A2 designate the first
setpoints corresponding the setpoint 16 of Figure 2 in the
respective base stations. The second setpoint of the base
stations is correspondingly designated by B1 and B2. The RNC

5 controls EB/No-setpoints of the base stations 4 and 4' by
providing both base stations with relative outer loop power
control (UP/DOWN) over an exemplifying Iub interface 19.

5   Figure 4 shows an embodiment in which the mobile station is
subjected to a soft handover procedure. As in the above, the
outer loop PC of a radio network controller can control
several Eb/No-setpoints in several BSs. However, Figure 4
discloses the possibility that all Eb/No-setpoints in a BS
10   are not controlled by the same controller. In this kind of
situation one of the controllers is the main controller while
the other controller is used for assisting in the control of
the station during the handover proceedings. In Figure 4 the
main controller comprises a serving RNC (S-RNC) 5 and the
15   assisting controller comprises a drifting RNC (D-RNC) 5'. The
serving and drifting RNC are connected to each other over an
exemplifying Iur interface 20. Since the overload indication
has now to be transmitted from the BS1 to the serving RNC 5
over two interfaces 19 and 20 and also through the drifting
20   RNC 5', the delay is even longer than what it would be in
Figures 2 or 3.

The serving RNC 5 of Figure 4 controls the outer loop PC.
However, the load control is performed by the load control 11
25   of the drifting RNC 5'. This means that in the case of a
power limitation situation (overload at BS1 in Figure 4), the
outer loop PC functionality performed by the serving RNC is
not interrupted, and thus the used Eb/No-setpoint (B1) and
Eb/No-setpoint of RNC (A,A1) start to drift. Moreover, the
30   Eb/No-setpoints (A2,B2) used for other handover branches can
also start to increase. However, this does not cause uplink
(UL) power increase as long as BS1 can control power of MS in
addition to BS2. The reason for this is that the MS will not

increase its transmission power as long as it receives at
least one DOWN command from at least one base station.

In a normal situation A1 A2 A and B1 A1 and B2 A2 in Figures
5   3 and 4. Because of the overload at the BS1 the Eb/No-
setpoints have started to drift. The controlling RNC allows
the system to return to the normal PC functionality after the
radio resource indication measurements have indicated that
the PrxTotal is below the set PrxTargetBS. After the cell has
10 returned back on the normal load state (PrxTotal <
PrxTargetBS) the outer loop PC is allowed again to control
the power levels at the BS. At this stage a drifting
detection unit 21 can define the amount of the drifting.

15 When the normal operation of the power control functionality
is allowed again, the drifting of the Eb/No-setpoints has to
be reduced. Base station BS1 can remove the drift (A1<>B1,
A2<>B2) internally, because it knows the actual used value
(B1,B2) and also the value in use in the RNC (A1,A2).
20 However, in order to avoid any too sharp changes in the
setpoint values, a gradual Eb/No-setpoint adjustment can be
accomplished. This can be done e.g. such that when an Eb/No-
setpoint down command is received from the RNC 5, the BS
checks drift of Eb/No-setpoints. If the check is positive the
25 drift is reduced instead of the actual Eb/No-setpoint. When
an Eb/No-setpoint up command is received in BS, then the
actual Eb/No-setpoint is always increased if the cell is not
overloaded.

30 Table 1 of Figure 5 shows various stages of the embodiment
for reducing a drift of Eb/No-setpoints between a BS and a
RNC when using the following parameters.

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SetUp                     = 0.5 dB
StepDown                  = 0.1 dB
Initial Eb/No-setpoint    = 4.1 dB
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5   It is noted that Table 1 shows the operation of an
     exemplifying power control mechanism using relative
     adjustments. However, the herein described principles can
     also be applied to a power control mechanism using absolute
     adjustment of the power levels.

10

     In Table 1 "A" is the Eb/No-setpoint of the RNC. "A1" and
     "A2" are the outer loop PC Eb/No-setpoint values of BS1 and
     BS2, respectively. BS1 and BS2 are both controlled by the
     same RNC. "B1" and "B2" are the Eb/No-setpoints used by the

15   closed loop PC. "B1" and B2" are controlled by the outer loop
     PC of the BS. "OFF" means that the outer loop PC
     functionality is switched off. In other words, when the OLPC
     is in "OFF" state, the adjustment of "B1" and "B2" is not
     allowed in base stations regardless the commands transmitted

20   by the OLPC. Correspondingly, adjustment of the "A1" and "A2"
     values is not allowed in the RNC. When the OLPC is switched
     "ON", this means that outer loop PC functionality is allowed
     again.

25   As explained, the OLPC/BS at the base station of the
     overloaded cell is frozen before the OLPC/RNC at the RNC
     becomes frozen and therefore an Eb/No-setpoint drifting may
     exist between the outer loops of the base station 4 and the
     radio network controller 5. Although the drifting can be

30   eliminated by using the algorithm described above, this may
     not be fast enough procedure in all occasions and some
     further processing may be required.

For instance, the OLPC/RNC might already have been
escalated/diverged, i.e. the Eb/No-setpoint of the OLPC/RNC
may have raised substantially (several dBs) during the last
RR indication period. This is caused partially because the RR
indication period (i.e. how often the RR indications are
sent) may be substantially long, wherein the OLPC/RNC will be
frozen a long time (up to one RR indication period) after the
OLPC/BS of the overloaded cell was frozen. The freezing of
the OLPC/BS may, however, have lead into a generation of
numerous frame errors (FE). The frame errors will increase
the FER. The increased FER will then further unnecessarily
increase the Eb/No-setpoint of the OLPC/RNC, and this will
increase further the drifting between the OLPC/BS and the
OLPC/RNC.

The above phenomena is one of the reasons why the normal
functionality of the OLPC/RNC may not be enough right after
the power limitation situation is over and the limiting or
freezing of the OLPC/BS and OLPC/RNC is cancelled. The
OLPC/RNC Eb/No-setpoint may have been drifted several dBs
above the situation the Eb/No-setpoint was during the
previous RR indication period just before the power
limitation is encountered in the RNC by a new RR indication
message from the BS. The OLPC/RNC drift can be defined in the
following manner:

$$OLPC/RNC \ DRIFT = Eb/No_2 - Eb/No_1$$
where
Eb/No_2 is the Eb/No-setpoint at the point when the
overload situation is over and the OLPC/RNC is no longer
frozen; and

Eb/No$_1$ is the last Eb/No-setpoint of a RR indication
period preceding the RR indication sent from the
overloaded BS.

5   The example presented in Table 2 of Figure 6 will clarify
further the embodiment. In Table 2 Eb/No1 is the last Eb/No-
setpoint of the previous RR indication period preceeding the
RR indication sent from the overloaded BS. EB/No2 is the
Eb/No-setpoint at the point of time when the overload
10   situation is over and the OLPC/RNC is no longer frozen. "A"
is the Eb/No-setpoint of the RNC. "A1" and "A2" are the outer
loop PC Eb/No-setpoint values of the BS, which are controlled
by the RNC. "B1" and "B2" are the Eb/No-setpoints used by the
closed loop PC, and are controlled by the outer loop PC of BS
15   (OLPC/BS). "OFF" means that the outer loop PC functionality
is switched off (i.e. adjusting of "B1" and "B2" is not
allowed in the BS or in the case of the RNC, adjusting of
"A1" and "A2" values is not allowed. "ON" means that the
outer loop PC functionality is allowed to return to normal
20   operation.

It is possible that the base station and the controller have
estimated a different amount of drift to be removed, e.g. due
to the different time of initiating the limitation / freezing
25   procedures. Therefore the algorithm cab be such that after
the OLPC/RNC is freed, the drift (= EbNo2 - EbNo1) will be
eliminated by decreasing the OLPC/RNC Eb/No-setpoint e.g. by
0.2 dB (normal decrease may be e.g. 0.1 dB) until the drift
equals zero or a new Frame Error occurs. At this stage the
30   drift elimination algorithm at the RNC is cancelled, the
Eb/No-setpoint is increased by e.g. 0.5 dB and a normal
OLPC/RNC action will follow. However, the OLPC/BS drifting

prevention algorithm described above may still operate until the drift thereof is removed in its entirety.

It should be appreciated that whilst embodiments of the
5 present invention have been described in relation to mobile stations, embodiments of the present invention are applicable to any other suitable type of user equipment.

The data is described as being in packet form. In alternative
10 embodiments of the invention the data may be sent in any suitable format.

The embodiment of the present invention has been described in the context of a CDMA system. This invention is also
15 applicable to any other access techniques including frequency division multiple access or time division multiple access as well as any hybrids thereof.

The embodiment of the invention has discussed the interaction
20 between a radio network controller and a base station. Embodiments of the present invention can be applicable to other network elements where applicable.

It is also noted herein that while the above describes one
25 exemplifying embodiment of the invention, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention as defined in the appended claims.